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The ecology of the microarthropod community inhabiting the moss cover of roofs

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With 8 figures

Synopsis: *Original scientific paper*

Three oribatid species (*Trichoribates trimaculatus*, *Scutovertex minutus* and *Phauloppia lucorum*), one springtail (*Xenylla sp.*) and a group of the actinedid mites were recorded from roof moss during a four-year qualitative and one-year quantitative investigations. The general, periodical environmental factors appear to have little influence on the life-cycles of these microarthropods in this isolated habitat. The oribatids *T. trimaculatus* and *S. minutus* spend their whole life-cycle in the moss-cover, but *Ph. lucorum* probably does not. Juveniles of the latter species were rare in moss in comparison to the other oribatids. *T. trimaculatus* seemed to be the best adapted microarthropod in this community.

Key words: Life-cycle, moss cover, *Trichoribates trimaculatus*, *Scutovertex minutus*, *Phauloppia lucorum*, reproduction, seasonal dynamics, abiotic factors.

1. Introduction

Moss represents a suitable environment for soil animals. Moss habitats on the soil surface in forests are part of a soil system continuous with underlying substrates, and affected by other plants on top of it. On the other hand, moss covers on rocks, trees and buildings are isolated from the influences of soil and herbs and possess their own thin soil layer on the solid substrate. The humidity and temperature fluctuation in these biotopes is caused especially by the following factors:

A. direct insolation with the strong accumulation of heat, and rapid increase of temperature;

B. the absence of any drainage especially on the horizontal solid substrate;

C. wind.

A number of authors have focused on the communities of mainly arboricolous covers (epiphytes), especially lichens (TRAVÉ, 1963; GJELSTRUP, 1979; GJELSTRUP & SØCHTING, 1984; ANDRÉ, 1979, 1983, 1984, 1985a, b), which are grazed by microarthropods. Mosses have been assumed rather to be refuges without any specific nutritive attraction for animals and their ecological characteristics seem to be of a different nature than those of lichens (SEYD, 1968, 1981; SEYD & SEAWARD, 1984). The seasonal dynamics of the microarthropod community have been described by ANDRÉ (1984) only. The direct effect of environmental factors, especially air pollution, has been studied in epiphytes and their dwellers by ANDRÉ *et al.* (1982) and ANDRÉ & LEBRUN (1982).

This paper contributes to the knowledge of the ecology of the animal community, its structure and seasonal dynamics in this isolated moss cover on roofs.

2. Material and methods

The structure of the microarthropod community of two biotopes was observed from 1981 until 1984, its quantitative ecological characteristics in 1984 only. They are situated approximately 100 km from each other: in the city of Kladno (415 m above sea level) and in the village of Všesoky near the town of Kutná Hora (600 m above sea level), both in central Bohemia, Czechoslovakia. The roofs of the small buildings differed as regards their material – tar paper (Kladno) and eternit (= asbestos shingles) (Všesoky). Moss – *Ceratodon purpureus* (HEDW.) BRID. – covered both roofs as a continuous coat ("continent") with the exception of the marginal parts of roofs, where moss grew as small, isolated "islands", approximately 3 cm in diameter. Moss was underlain by homogeneous, fine, blown soil. The thickness of both layers (moss and soil) reached approximately 2 cm together. The cores within one monthly sampling unit (10 cores per unit) were each 5 cm × 5 cm. Each small "island" represented one core (12 per unit).

The water content in moss was estimated after extraction in Tullgren funnels (in 35 °C for 7 days) as the difference between fresh (wet) and dry mass respectively (fig. 1). Microarthropods were fixed in 80% ethyl alcohol.

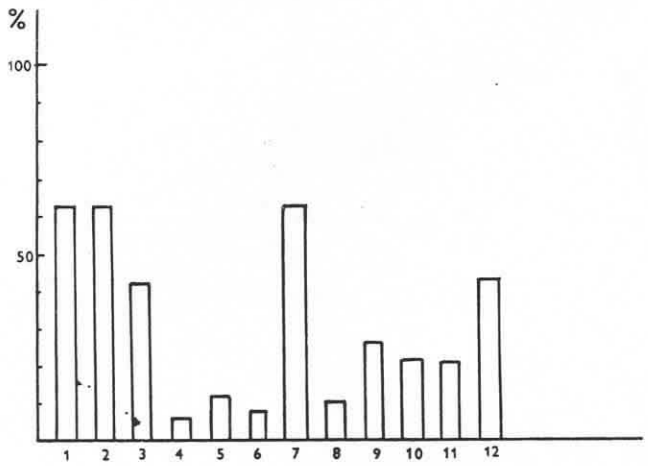

Fig. 1. Mean water content in monthly samples (1984).

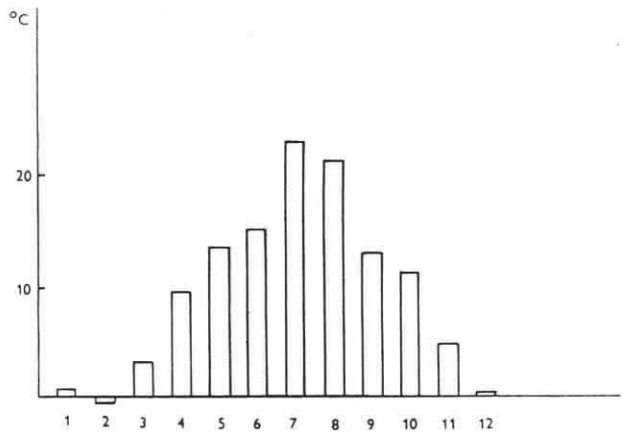

Fig. 2. Mean monthly temperature in 1984 (Kladno).

The community structure was very stable during the period of observation. Moreover, the differences between the biotopes were negligible, in spite of the different materials of roofs from each other, as regards the ecological characteristics estimated. Therefore, the data from Kladno only are presented.

Microarthropods studied:

Scutovertex minutus (KOCH, 1836) (Acari: Oribatida)
Trichoribates trimaculatus (KOCH, 1836) (Acari: Oribatida)
Phauloppia lucorum (KOCH, 1841) (Acari: Oribatida)
Xenylla sp. (undetermined species) (Collembola)
Actinedida (Acari) (undetermined species).

For oribatids, adults and juveniles represented two separated groups in this analysis. Other arthropods (Acari: Gamasida: Gamasina; Insecta: several groups) were found rarely and in small numbers. They were not, therefore, included in these studies because their significance for the structure and dynamics of the community was low. The mean number of specimens per core extrapolated per 10 g of dry mass (dm_x) of core, their C_V (variation coefficient), frequency and dominance respectively were estimated for each group studied.

3. Results

Scutovertex minutus, *Trichoribates trimaculatus*, *Xenylla sp.* and actinedids were sampled every month, although not in all cores within one monthly sampling unit. Thus, their monthly frequency was above zero in sampling units during the year. Nevertheless, Actinedida reached 100% frequency in cores within one sampling unit in November only, when their abundance was the highest (tab. 1). A similar phenomenon appeared in *Xenylla sp.* in January and July. *S. minutus*, on the whole (adults and juveniles together) exhibited 100% frequency eight times in the year in cores of the monthly sampling unit. It was three times due to adults only, once due to juveniles only, twice due to 100% frequency of both, and twice due to complementarity, i.e. as a sum of both. *T. trimaculatus* was found in four months with 100% frequency of adults only, and for three months due to both. *Ph. lucorum*, however, occurred in all cores within the monthly sample unit in three months, always due to 100% frequency of adults only. On the other hand, this species was lacking entirely during two months. Juveniles of *Ph. lucorum* were infrequent in moss in comparison to other oribatid juveniles. Moreover, the ratio of the juvenile stages (larvae/protonymphs/deutonymphs/tritonymphs) of the latter was approximately equal, without any remarkable dominance of any stage within monthly sampling units or cores during the year. *Ph. lucorum* nymphs, however, belonged to the third stage only.

Juveniles of *S. minutus* and *T. trimaculatus* were the numerically dominant groups (tab. 1, fig. 3) (cf. juveniles of *Ph. lucorum*). The monthly estimated dominances, however, exhibited some fluctuation. *T. trimaculatus* juvenile dominance was very high in February, April and December (over 50%). Although juveniles of *S. minutus* and springtails show high dominance as well, they did not at any time reach 50%.

Although the cores were approximately of the same size, fluctuation in the water content (fig. 1) can affect comparative results. Therefore, the extrapolation to 10 g of the dry mass (dm_x) was used for comparison. (tab. 1). The seasonal dynamics of *S. minutus* exhibited the main maximum in July (adults), but three lower peaks occurred in juveniles (fig. 4). Juveniles of *T. trimaculatus*, in addition to the main extreme peak in October, had several lower ones during the year, whereas seasonal dynamics of adults fluctuated more moderately in comparison to the above mentioned groups (fig. 5). The lower numbers of specimens of *Ph. lucorum* did not provide significant results in every month (fig. 6). Juveniles (tritonymphs only) of *Ph. lucorum* were infrequent in moss studied, therefore their seasonal dynamics could not be significantly estimated. The main springtail peaks (adults and juveniles together) in January and July were followed by lower ones in autumn (fig. 7). Actinedids, on the other hand, exhibited their extreme high peaks in November and October (fig. 8). Variation coefficients were calculated for the monthly values of abundance for

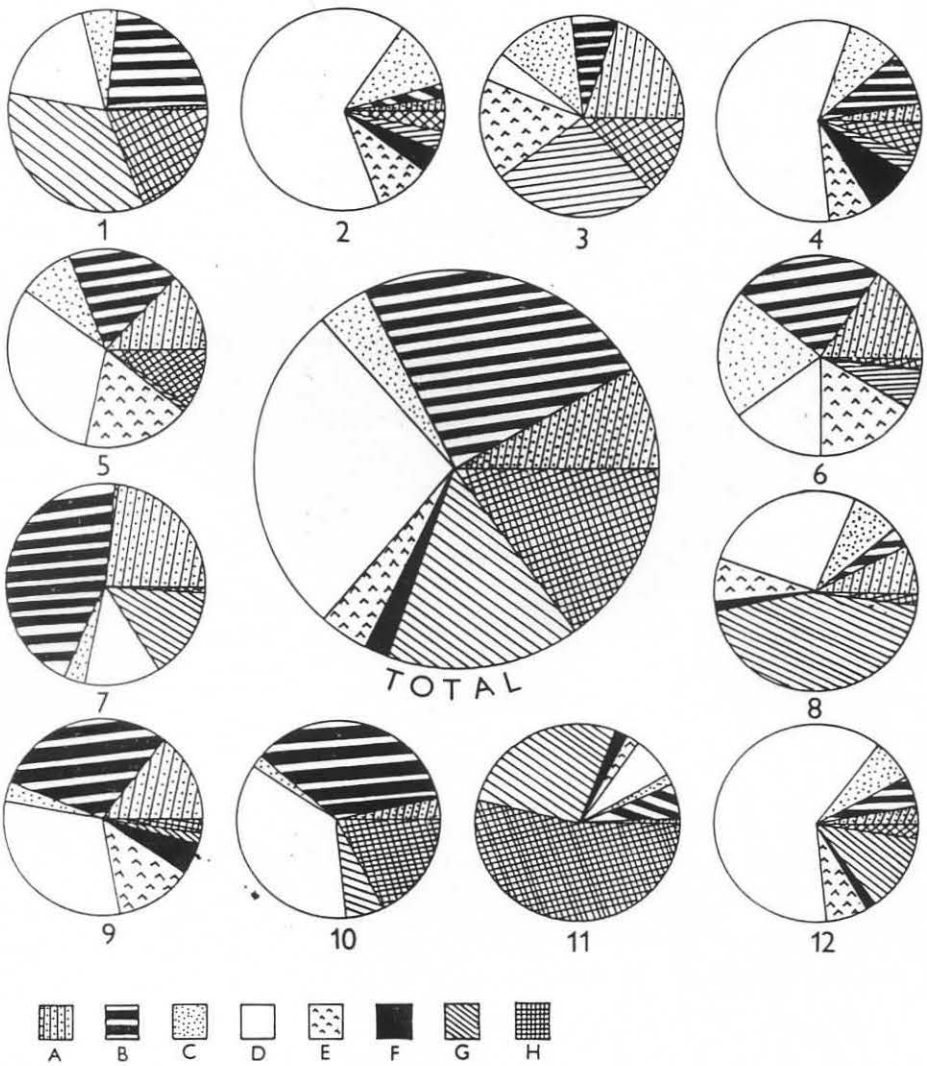

Fig. 3. Monthly values of dominance of microarthropods studied and their total dominance in the year 1984 (centre). Symbols used: A – *Scutovertex minutus*, adults; B – *S. minutus*, juveniles; C – *Trichoribates trimaculatus*, adults; D – *T. trimaculatus*, juveniles; E – *Phauloppia lucorum*, adults; F – *Ph. lucorum*, juveniles; G – *Xenylla sp.*; H – Actinedida.

some orientation, to indicate the aggregation trend in the population distribution. This is true for its value over 1. (*cf.* SMRŽ & JUNGOVÁ, 1989).

The structure of the community in the small, isolated moss "islands" differed from the parts divided from the continuous cover ("continent"). They were sampled in November and December, when the oribatid population did not reach its maximal level. Only Actinedida exhibited their peak in November. The cores per 5 g (November) show the higher diversity in spite of the lower numbers of *Ph. lucorum* (adults and juveniles). They contained adults and juveniles of *T. trimaculatus* and lower number of actinedids. On the other hand, *S. minutus* in spite of dominance in "continental" cores, was lacking in those "islands". Springtails were sampled in "islands" very rarely, one specimen per core only.

Table 1. Mean number (n) and variation coefficient (C_V) of microarthropods studied extrapolated per 10 g dm_x (A = adults, J = juveniles, NS = non-significant, very small values).

Month	*Scutovertex minutus*				*Trichoribates trimaculatus*				*Phauloppia lucorum*				*Xenylla sp.*		Actinedida	
	A		J		A		J		A		J					
	n	C_V	n	C_V	n	C_V	n	C_V	n	C_V	n	C_V	n	C_V	n	C_V
1.	4	0.7	108	0.8	25	0.8	86	0.7	0	–	0	–	167	0.8	78	0.8
2.	2	0.7	2	0.6	9	0.7	60	0.6	7	0.9	NS	–	3	0.8	3	1.4
3.	3	0.9	1	1.6	2	0.7	1	1.3	3	0.8	0	–	4	0.8	1	2.3
4.	1	0.4	1	0.8	1	1.0	4	1.2	1	0.6	NS	–	1	0.8	1	2.3
5.	2	0.7	3	0.8	2	0.8	8	1.1	3	0.5	0	–	NS		2	0.7
6.	4	0.7	13	1.0	11	1.2	8	1.0	10	0.9	0	–	10	0.9	3	0.5
7.	109	0.6	170	0.5	14	0.7	47	0.8	0		0	–	75	0.8	9	1.6
8.	2	1.3	1	1.0	2	1.0	5	1.8	2	1.3	NS	–	9	2.3	1	0.8
9.	24	1.3	65.	1.9	5	0.6	55	1.0	17	1.6	NS	–	5	1.1	1	2.3
10.	14	0.5	125	1.0	6	0.5	131	1.1	0		0	–	22	0.9	49	1.1
11.	1	1.8	3	2.1	2	1.0	9	1.4	2	1.5	NS	–	35	1.0	86	1.0
12.	2	0.6	3	1.8	4	1.1	15	1.7	3	1.1	NS	–	5	1.3	1	1.0

Abundance of *T. trimaculatus* adults per 10 g, extrapolated for the comparison to "continent" values, did not differ substantially in either type of moss cover. Juveniles of this species, however, surmounted in "islands" six times those values in "continent". The above mentioned trends were more remarkable in cores per 0.5 g (December). The presence of one species only – *T. trimaculatus* (adults and juveniles) – and its very high abundance, confirmed its preference for this type of biotope. However, it must be emphasized that the values of the extrapolations above mentioned are theoretical because of the aggregation trends in the distribution of soil animals. Nevertheless, these characteristics may be used for the orientation and general comparison.

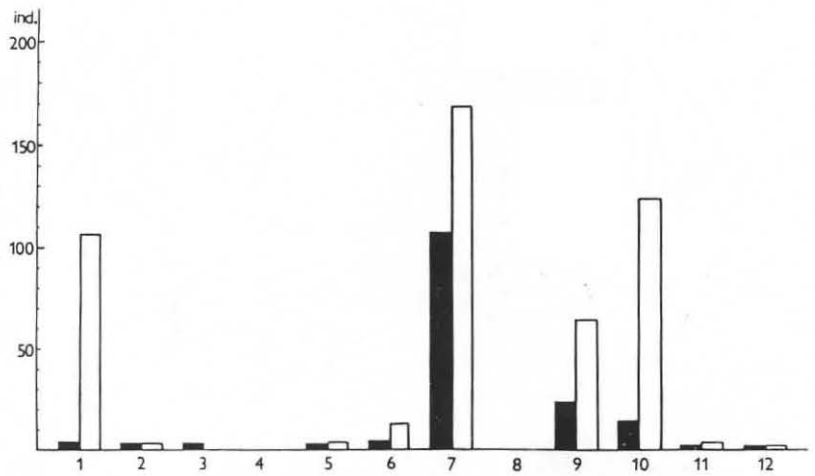

Fig. 4. Abundance per 10 g dm_x of core of *Scutovertex minutus* (1984). Black columns – adults, empty ones – juveniles.

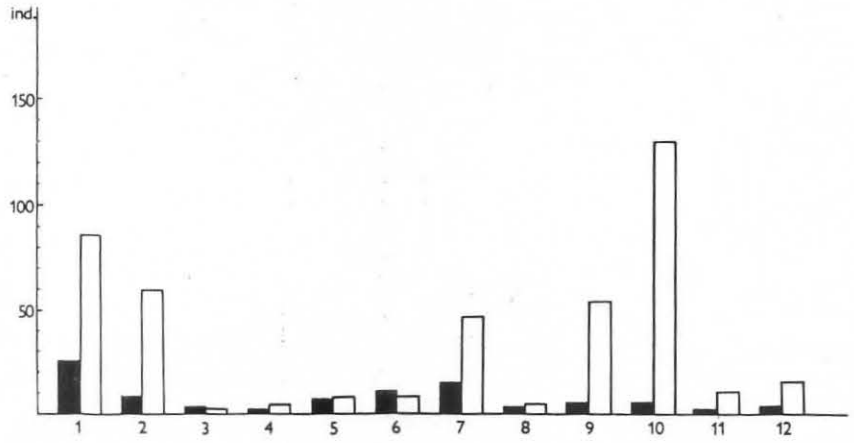

Fig. 5. Abundance per 10 g dm_x of core of *Trichoribates trimaculatus* (1984). Black columns – adults, empty ones – juveniles.

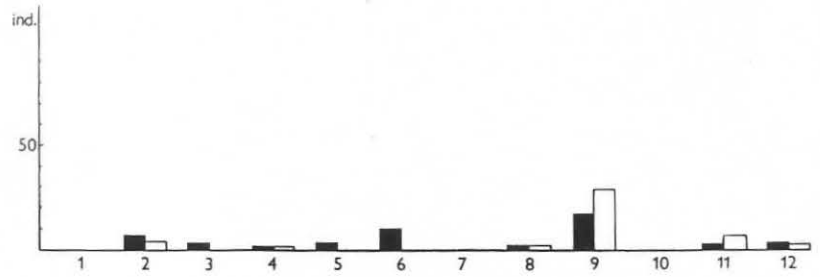

Fig. 6. Abundance per 10 g dm_x of core of *Phauloppia lucorum* (1984). Black columns – adults, empty ones – juveniles.

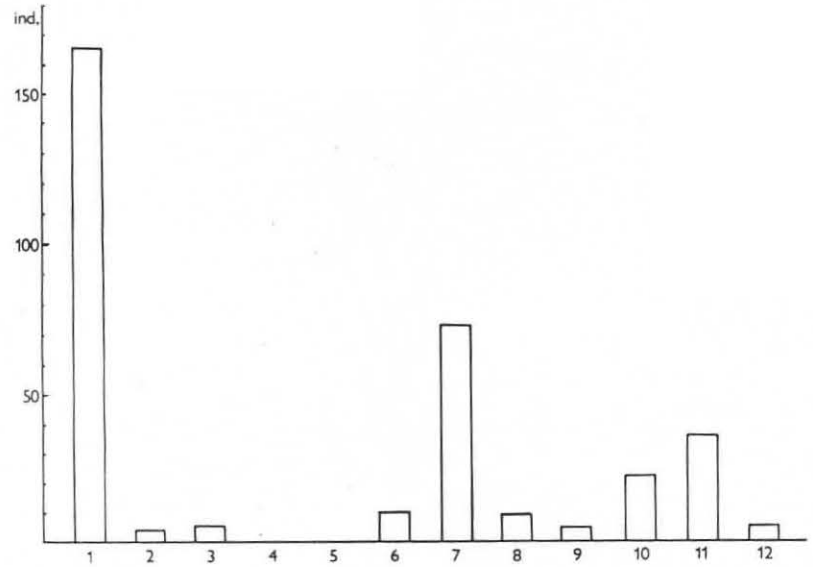

Fig. 7. Abundance per 10 g dm_x of core of *Xenylla sp.* (1984).

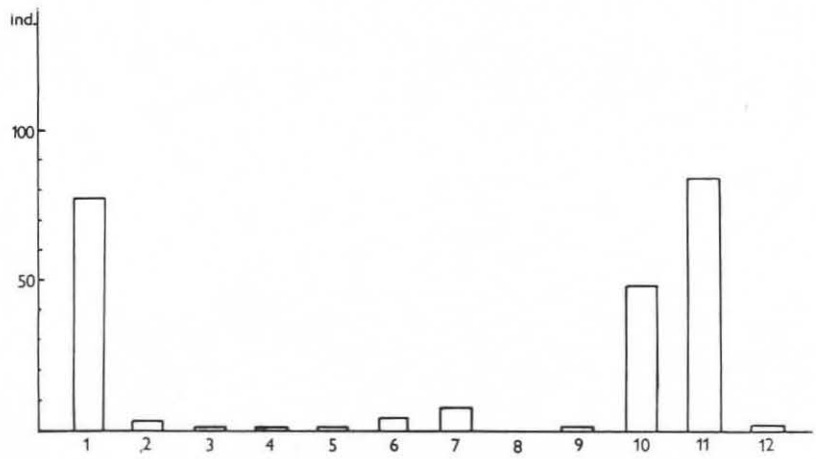

Fig. 8. Abundance per 10 g dm_x of core of Actinedida (1984).

Table 2. Abundance, mean number and variation coefficient (C_V) of microarthropods studied in "islands" of moss.

	Number per core		C_V	Number per 10 g dwt		C_V	Adults/juveniles ratio per sample
	mean	maximal		mean	maximal		
5 g cores (November)							
Trichoribates trimaculatus							
adults	1	2	0.4	3	5	0.3	0.01
juveniles	22	45	0.6	58	129	0.6	
Phauloppia lucorum							
adults	1	3	1.3	2	7	1.5	0.10
juveniles	8	30	1.6	non-significant			
Xenylla sp.	non-significant (5 specimens totally)						
Actinedida	17	23	0.6	38	51	0.6	
0.5 g cores (December)							
Trichoribates trimaculatus							
adults	1	2	0.7	12	42	1.5	0.04
juveniles	51	185	1.1	1602	5781	0.5	

4. Discussion

The three oribatids recorded and *Xenylla sp.* have frequently been reported in the literature from epilithic and epiphytic mosses, algae and foliose lichens (ANDRÉ, 1979, 1983, 1984; GJELSTRUP & SØCHTING, 1984). The latter authors estimated the increasing selectivity of habitat in this order: *Ph. lucorum* – *T. trimaculatus*, whereas the records of WEIGMANN & KRATZ (1981) indicate the following ordering: *S. minutus* – *Ph. lucorum* – *T. trimaculatus*. STRENZKE (1952) placed *T. trimaculatus* and *Ph. lucorum* into his *Zygoribatula exilis* – community in moss or lichen cover of the solid substrates.

The abundance of oribatids (especially *T. trimaculatus*) was several times higher in this moss cover per core or per 10 g dm_x than in lichens observed by ANDRÉ (1984) who found 58 mites per dm^2 (*cf.* extrapolation into 10 g dm_x!). It may be explained by the greater living space, but also by more buffered environments against the fluctuation of abiotic factors. The moss cover rather resembles soil habitat due to its thickness and underlying soil sayer. It corresponds to "suspended soils" *sensu* DELAMARE-DEBOUTTEVILLE (1948) (see also GJELSTRUP, 1979).

T. trimaculatus and *S. minutus* differed from each other with respect to their seasonal dynamics, but their populations were approximately of the same total numbers as a whole. Their life- and reproductive cycles seem to be governed by humidity, which fluctuates very suddenly and non-periodically in moss covers. This factor affects mites as much directly as by regulation of their food, mainly microorganisms. The mode of reproduction of some oribatids, based on the continuous presence of eggs within females during the whole year (LUXTON, 1981; SMRŽ, 1989a, b) renders the operative response to the sudden changes of abiotic factors, Therefore, *T. trimaculatus* and *S. minutus* show several peaks during the season. These species and *Xenylla sp.* exhibited three months periodicity of peaks, mainly of juveniles, with some disruption in spring. This periodicity may be associated with the humidity fluctuation and time of ontogenical development, especially egg hatching. Several authors (HARTENSTEIN, 1962; WOODRING & COOK, 1962; ROCKETT & WOODRING, 1976) gave the life-cycle from egg to adult in some ceratozetids as about 80–90 days (i.e. approximately three months). Several peaks mentioned, however, do not suggest the polyvoltinity of the mites studied, which have been considered to be mainly univoltine (LUXTON, 1981). This distribution of peaks probably expresses the occurrence of several overlapping generations within one population as a consequence of an interaction between fluctuating abiotic environmental factors and the ability to lay eggs, when these factors permit, during almost any time of the year.

The alternation of abundance and dominance of *T. trimaculatus* and *S. minutus* may also be explained by the nutritional biology, food selection and type of digestion of both species (SMRŽ, 1992), which enable the more thorough employment of the food sources – mainly microorganisms – which have various seasonal dynamics as well. The seasonal dynamics of abundance and dominance of *Ph. lucorum*, springtails and actinedids correspond to those common in microathropods in soil, with a more obvious maximum in autumn. In actinedids, some correlations can be estimated between their abundance and dominance maximum and the minimal values of the other microarthropods studied. It may result from the predatory role of actinedids. This group is very mobile with the ability to invade various habitats (HERMOSILLA, 1976; HUTSON, 1980; SMRŽ & JUNGOVÁ, 1989). Their migration should be assumed in these studies as well.

The high juvenile abundance and frequency of *T. trimaculatus* and *S. minutus* indicate that the whole life-cycle of these species is spent in moss on the roofs. The relatively stable adults/juveniles ratio of these species decreased appreciably in the reproduction peaks only. Adults of the species *Ph. lucorum* reached approximately the same numbers in cores as *T. trimaculatus*. Juveniles of the latter species, however, were fifteen times more abundant than those of *Ph. lucorum* represented by tritonymphs only. The extremely high adults/juveniles ratio may be explained in various ways:

1. a part of life cycle, especially the earlier juvenile stages, is spent out of the moss cover;
2. the juvenile period proceeds very rapidly in moss, probably in the suitable humidity;
3. juveniles digging within moss tissues are unable to withdraw before or during extraction, as is the case with some other species (LUXTON, pers. commun.).

The values of C_V indicate the trend to aggregations in the period of lower population density, whereas at maximum density a great number of juveniles probably migrate and disperse throughout most of area inhabited.

The differences as regards distribution of both dominant oribatids appeared strongly in small "islands", which resulted probably from a greater aggregability of *S. minutus* (absent in the smallest "islands") unlike *T. trimaculatus* (the only microarthropod in these

"islands"). The lower C_V-values of *T. trimaculatus* may be caused by the rapid population expansion within the limited area of "islands". Although the extrapolated abundances per 10 g dm_x are of theoretical importance only, the actual values are striking as well. We can conclude the great ecological tolerance of *T. trimaculatus*, its adaptability and ability to colonize such simple, pioneer habitats. Actinedida and springtails, in spite of their mobility and, hence, migration trends, did not invade these "islands".

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